CLAIMS AS AMENDED

1. (Amended) A method for treating a material, comprising:
forming an ozone-solvent solution at a first temperature; and
reacting the ozone-solvent solution with the material at a second temperature;
wherein the first temperature is less than the second temperature, the relatively lower first temperature facilitating an increased concentration of dissolved ozone in the solvent, the relatively higher second temperature facilitating an increased reaction rate between the ozone-solvent solution and the material; and
wherein the reacting step comprises:
heating said ozone-solvent solution from said first temperature to substantially said second temperature to form a heated ozone-solvent solution; and
after said step of heating said ozone-solvent solution, applying said heated ozone-solvent solution to the material at said second temperature.

2. (Original) The method of claim 1, wherein said ozone-solvent solution is formed at said first temperature by dissolving an ozone gas in solvent at said first temperature.
3. (Original) The method of claim 1, wherein the second temperature is at least 5 degrees Celsius greater than the first temperature.
4. (Original) The method of claim 3, wherein the first temperature is between 1 and 30 degrees Celsius.
5. (Original) The method of claim 3, wherein the first temperature is between 1 and 10 degrees Celsius.
6. (Original) The method of claim 3, wherein the second temperature is between 30 and 95 degrees Celsius.
7. (Original) The method of claim 3, wherein the second temperature is between 35 and 65 degrees Celsius.
8. Cancelled
9. (Amended) The method of Claim [8] 1, wherein said heated ozone-solvent solution is applied to the material within a time period after heat is first applied to said ozone-solvent solution for heating said ozone-solvent solution from said first temperature to the said second temperature to minimize a decrease in concentration of the dissolved ozone in the ozone-solvent solution resulting from heating the ozone-solvent solution.
10. (Original) The method of claim 9, wherein the time period is set to a predetermined value such that the concentration of the ozone-solvent solution applied to the material at said second temperature is greater than if said ozone-solvent solution had been formed at said second temperature.
11. (Original) The method of Claim 9, wherein the time period corresponds to no more than a 20 percent decrease in the concentration of the dissolved ozone in the ozone-solvent solution from the concentration at the first temperature.
12. (Original) The method of Claim 1, wherein reacting said ozone-solvent solution with material comprises applying the ozone-solvent solution to the material using at least one nozzle.
13. (Original) The method of Claim 1, wherein reacting the ozone-solvent solution with the material comprises immersing the material within the ozone-solvent solution.
14. (Amended) The method of claim [8] 1, wherein said step of applying said heated ozone-solvent solution to said material has at least one point of application, and wherein the

step of heating comprises using a liquid-to-liquid heat exchanger placed just upstream of the at least one point of application of said heated ozone-solvent solution to said material.

15. (Amended) The method of claim [8] 1, wherein said step of applying said heated ozone-solvent solution to said material has at least one point of application, and wherein the heated ozone-solvent solution is heated using an in-line heater placed just upstream of the at least one point of application of said heated ozone-solvent solution to said material.

16. Cancelled

17. (Original) The method of Claim 1, further comprising:
injecting and mixing a chemical into said ozone-solvent solution prior to reacting said ozone-solvent solution with said material.

18 (Original) The method of Claim 1, further comprising:
injecting a chemical into said ozone-solvent solution;
immediately prior to reacting said ozone-solvent solution with said material.

19. (Original) The method of Claim 17, wherein the chemical comprises a hydroxyl radical scavenger.

20. (Original) The method of Claim 17, wherein the chemical comprises an element selected from the group consisting of a pH buffer, an acid, and a base.

21. (Original) The method of Claim 17, wherein the chemical comprises a corrosion inhibitor.

22. (Original) The method of Claim 17, wherein the chemical comprises a surfactant.

23. (Original) The method of Claim 1, wherein the reacting step comprises applying said ozone-solvent solution to said material while transferring sufficient heat to at least one of said material and said ozone-solvent solution to react said ozone-solvent solution with said material at approximately said second temperature.

24. (Original) The method of Claim 1, wherein said material comprises a substrate, and wherein the step of reacting said ozone-solvent solution with said substrate comprises:
spinning said substrate to achieve a rotational speed about an axis; and
dispensing said ozone-solvent solution over the spinning substrate using at least one nozzle.

25. (Original) The method of Claim 24, wherein said at least one nozzle is positioned on said axis.

26. (Original) The method of Claim 24, wherein a plurality of nozzles are positioned in a plurality of positions over the substrate.

27. (Original) The method of Claim 1, wherein said material comprises a substrate, said method further comprising the step of rinsing the substrate after the substrate is treated with said ozone-solvent solution.

28. (Original) The method of Claim 1, wherein the material comprises a planar substrate selected from the group consisting of semiconductor wafers, flat panel displays, and memory discs, substrates for use in an electronic device.

29. (Original) The method of Claim 1, wherein the material is selected from the group consisting of photoresist, post etch resist residue, post etch residue, anti-reflective coating, organic contamination.

30. Cancelled

31. (Amended) A method for oxidizing a material, comprising:

dissolving an ozone gas in solvent at a first temperature to form an ozone-solvent solution;

heating the ozone-solvent solution from the first temperature to a second temperature; and

after the step of heating the ozone-solvent solution, reacting the heated ozone-solvent solution with the material at approximately the second temperature to oxidize the material,

wherein dissolving the ozone gas in solvent at the cooler first temperature allows for a higher concentration of dissolved ozone in the solvent, and the warmer second temperature allows for a higher reaction rate between the ozone-solvent solution and the material.

32. (Original) The method of Claim 31, further comprising rinsing the material.
33. (Original) The method of Claim 31, wherein the second temperature is at least 5 degrees Celsius greater than the first temperature.
34. (Original) The method of Claim 31, wherein the first temperature is between 1 and 30 degrees Celsius.
35. (Original) The method of Claim 31, wherein the second temperature is between 30 and 95 degrees Celsius.
36. (Original) The method of Claim 31, wherein reacting the ozone-solvent solution with the material comprises applying the ozone-solvent solution to the material.
37. (Original) The method of Claim 36, wherein the ozone-solvent solution is heated prior to applying the ozone-solvent solution to the material.
38. Cancelled
39. (Original) The method of Claim 31, further comprising:

injecting a chemical into the ozone-solvent solution prior to applying the ozone-solvent solution to the material.

40-115, withdrawn from consideration due to restriction requirement

116. (Original) The method of Claim 24, further comprising the step of moving said nozzle relative to said substrate.

[121.] 120. (New) The method of claim 1, wherein said step of applying said heated ozone-solvent solution to said material comprises passing said heated ozone-solvent solution through an orifice that directs said heated ozone-solvent solution toward said material, and wherein the step of heating comprises using a liquid-to-liquid heat exchanger placed just upstream of said orifice to heat said ozone-solvent solution.

[122.] 121. (New) The method of claim 1, wherein said step of applying said heated ozone-solvent solution to said material comprises passing said heated ozone-solvent solution through an orifice that directs said heated ozone-solvent solution toward said material, and wherein the ozone-solvent solution is heated in the heating step using an in-line heater placed just upstream of said orifice.

Claims 40-115 withdrawn from consideration

40. A device for treating a material, comprising:

means for forming an ozone-solvent solution at a first temperature; and

means for reacting the ozone-solvent solution with the material at a second temperature greater than the first temperature to oxidize at least a portion of the material;

wherein the lower first temperature facilitates an increased concentration of dissolved ozone in the solvent, and the higher second temperature facilitates an increased reaction rate between the ozone-solvent solution and the material.

41. The device of Claim 40, wherein the means for forming an ozone-solvent solution at a first temperature comprises:

a source of solvent at a first temperature;

a source of ozone gas;

an ozone gas-solvent contactor for dissolving ozone gas into said solvent at a first temperature to form an ozone-solvent solution;

42. The device of Claim 40, wherein the means for reacting comprises:

delivery means for delivering the ozone-solvent solution to the material to be treated;

application means to apply the ozone-solvent solution to the material;

heating means to facilitate the reaction between the ozone-solvent solution and the material at approximately the second temperature.

43. The device of Claim 42, further comprising an open vessel for holding the material to be treated.

44. The device of Claim 42, further comprising a closed vessel for holding the material to be treated.

45. The device of Claim 42, wherein the heating means comprises a heater connected between the delivery means and the dispensing means to heat the ozone-solvent solution prior to reaching the material to be treated.

46. The device of Claim 45, wherein the heating means comprises an in-line heater.

47. The device of Claim 45, wherein the heating means comprises a liquid-to-liquid heat exchanger.

48. The device of Claim 42, wherein the heating means comprises a heater configured to heat at least one of the ozone-solvent solution and the material to be treated, while said solution is being applied to the material.

49. The device of Claim 48, wherein the heater comprises one element selected from the group consisting of a radiant heater, a conduction heater and a convection heater.

50. The device of Claim 48 wherein the heater comprises a convection heater which provides a heated fluid, and wherein said material comprises a substrate having two opposing sides, and wherein the heated fluid is applied to a side of the substrate opposite to that to which the heated ozone-solvent solution is applied.

51. A method of treating a material, comprising:

forming an ozone-solvent solution at a first temperature having a dissolved ozone concentration;

reacting said ozone-solvent solution with the material at a second temperature which is higher than said first temperature.

52. The method of claim 51, wherein the reacting step comprises:

heating at least one of said ozone-solvent solution and the material;

thereby causing said ozone-solvent solution to have a higher dissolved ozone concentration while reacting with the material than if said ozone-solvent solution had been formed at said second temperature.

53. The method of claim 52, wherein said reacting step comprises heating said ozone-solvent solution quickly from said first temperature and quickly reacting said ozone-solvent solution with said material in order to maintain a higher dissolved ozone concentration than if said ozone-solvent solution had been formed at said second temperature.
54. The method of claim 53 wherein said reacting step comprises applying said ozone-solvent solution to the material.
55. The method of claim 54 wherein said applying step comprises dispensing said ozone-solvent solution from at least one solid steam nozzle onto the material.
56. The method of claim 54 wherein said applying step comprises moving either of said at least one nozzle and the material relative to the other to improve uniformity of treatment.
57. The method of claim 54 wherein the material comprises a planar surface, and wherein said applying step comprises rotating said planar surface about an axis normal to said planar surface while contacting said material with said ozone-solvent solution.
58. The method of claim 54 wherein said applying step comprises immersing said material in said ozone-solvent solution in an immersion processing module.
59. The method of claim 58 wherein the material comprises a planar surface, and wherein said applying step comprises rotating said planar surface about an axis normal to said planar surface while contacting said material with said ozone-solvent solution.
60. The method of claim 52, further comprising:

prior to reacting the ozone-solvent solution to the material, injecting a chemical into said ozone-solvent solution.
61. The method of claim 60, wherein said chemical comprises an element selected from the group consisting of carbonates, phosphates, bicarbonates, carboxylic acids, phosphonic acids, salts of carboxylic acids, salts of phosphonic acids.
62. The method of claim 60, wherein said chemical comprises a hydroxyl radical scavenger.
63. The method of claim 60, wherein said chemical comprises an element selected from the group consisting of borates, boric acid, salts of boric acid, biborates, pentaborates, ammonium biborate, ammonium pentaborate, sulfates, ammonium sulfate.
64. The method of claim 60, wherein said chemical comprises a buffer.
65. The method of claim 60, wherein said chemical comprises a corrosion inhibitor.
66. The method of claim 60, wherein said chemical comprises a surfactant.
67. The method of claim 60, wherein said chemical comprises a plurality of chemicals selected from the group consisting of a hydroxyl radical scavenger, a buffer, a corrosion inhibitor, and a surfactant.
68. The method of claim 53, wherein the ozone-solvent solution is heated using a liquid-to-liquid heat exchanger.
69. The method of claim 53, wherein the ozone-solvent solution is heated using an in-line solvent heater.
70. The method of claim 52, wherein the reacting step comprises heating the material.

71. The method of claim 51, wherein the step of forming said ozone-solvent solution comprises:

providing solvent at said first temperature; and

dissolving ozone gas in said solvent.

72. The method of claim 71, wherein said first temperature is below ambient temperature, and the step of providing solvent at said first temperature comprises cooling said solvent to said first temperature.

73. The method of claim 52, wherein the step of forming said ozone-solvent solution comprises:

providing solvent at said first temperature; and

dissolving ozone gas in said solvent.

74. The method of claim 73, wherein said first temperature is below ambient temperature, and the step of providing solvent at said first temperature comprises cooling said solvent to said first temperature.

75. The method of claim 51, wherein the reacting step comprises:

heating the material to a higher temperature than said first temperature;

applying said ozone-solvent solution to said heated material thereby causing the heated material to be reacted with said ozone-solvent solution at said second temperature.

76. The method of claim 51, wherein the reacting step comprises

applying said ozone-solvent solution to the material;

wherein the temperature of the material is higher than said first temperature.

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77. A system for treating a substrate with an ozone-solvent solution comprising:

a supply of an ozone-solvent solution formed at a first temperature which delivers a generally continuous supply of said ozone-solvent solution at the first temperature;

a heater having an inlet and an outlet, said inlet fluidly coupled to receive said ozone-solvent solution at said first temperature from said supply, said heater configured to heat from said first temperature said ozone-solvent solution received at said inlet, said outlet providing a generally continuous supply of heated ozone-solvent solution; and

an applicator fluidly coupled to the outlet of said heater to receive said generally continuous supply of said heated ozone-solvent solution, said applicator having an outlet configured to direct said heated ozone-solvent solution at a second temperature greater than said first temperature toward said substrate.

78. The system of claim 77, wherein said supply of a ozone-solvent solution formed at a first temperature comprises:

an ozone-solvent contactor, said contactor having a fluid inlet, a gas inlet, a gas outlet, and an ozone-solvent outlet;

a supply of solvent at approximately said first temperature fluidly coupled to the fluid inlet of said ozone-solvent contactor;

a supply of ozone gas fluidly coupled to the gas inlet of said ozone-solvent contactor; and

a gas receiving vent fluidly coupled to the gas outlet of said ozone-solvent contactor.

79. The system of claim 78, wherein the supply of solvent at approximately said first temperature comprises:

a source of solvent;

a heater/chiller fluidly coupled to said source of solvent, said heater/chiller controlling the temperature of said solvent to provide said solvent at approximately said first temperature.

80. The system of claim 77, wherein the second temperature is at least 5 degrees C greater than the first temperature.

81. The system of claim 77, wherein the first temperature is in the range of about 1degree C to about 15 degree C.

82. The system of claim 77, wherein the second temperature is in the range of about 35degree C to about 65 degree C.

83. The system of claim 77, wherein said applicator outlet comprises a dispense nozzle.

84. The system of claim 77, wherein said applicator comprises:

an injected chemicals supply;

an injector-mixer having an injection port which is fluidly coupled to said injected chemicals supply and an outlet which provides said ozone-solvent solution and an admixture of injected chemicals from said injected chemicals supply; and

wherein said outlet of said applicator comprises a dispense nozzle fluidly coupled to the outlet of said injector-mixer.

85. The system of claim 77, further comprising:

a materials processing module with a least one fluid inlet and one fluid drain; and

wherein said applicator further comprises:

an injected chemicals supply;

an injector-mixer having an injection port which is fluidly coupled to said injected chemicals supply and an outlet which provides said ozone-solvent solution and an admixture of a predetermined quantity of injected chemicals from said injected chemicals supply; and

wherein said outlet of said applicator comprises a dispense nozzle fluidly coupled to the outlet of said injector-mixer.

86. The system of claim 77, wherein said substrate comprises one or more surfaces, and wherein said applicator comprises:

a materials processing module with a least one fluid inlet and one fluid drain;

an injected chemicals supply;

an injector-mixer having an injection port which is fluidly coupled to said injected chemicals supply and an outlet which provides said ozone-solvent solution and an admixture of a predetermined quantity of injected chemicals from said injected chemicals supply; and

wherein said outlet of said applicator comprises one or more dispense nozzles fluidly coupled to the outlet of said injector-mixer and positioned to dispense onto said one or more surfaces of the substrate at approximately said second temperature said ozone-solvent solution and said admixture.

87. The system of claim 77, wherein said substrate comprises a planar surface, and wherein said applicator comprises:

a substrate spinner configured to spin said substrate about an axis normal to said planar surface; and

wherein said outlet of said applicator comprises a dispense nozzle positioned to dispense onto said planar surface the ozone-solvent solution at said second temperature.

88. The system of claim 77, wherein said substrate comprises a planar surface, and wherein said applicator comprises:

a substrate spinner configured to spin said substrate about an axis normal to said planar surface;

an injected chemicals supply;

an injector-mixer having an injection port which is fluidly coupled to said injected chemicals supply and an outlet which provides said ozone-solvent solution and an admixture of a predetermined quantity of injected chemicals from said injected chemicals supply; and

wherein said outlet of said applicator comprises a dispense nozzle positioned to dispense onto said planar surface the ozone-solvent solution and said admixture at approximately said second temperature.

89. The system of claim 77, wherein said substrate comprises a planar surface, and wherein said applicator comprises:

a materials processing module;

a substrate spinner located inside said materials processing module, said spinner configured to spin said substrate about an axis normal to said planar surface;

an injected chemicals supply;

an injector-mixer having an injection port which is fluidly coupled to said injected chemicals supply and an outlet which provides said ozone-solvent solution and an admixture of a predetermined quantity of injected chemicals from said injected chemicals supply; and

C1 wherein said outlet of said applicator comprises a dispense nozzle positioned to dispense onto said planar surface the ozone-solvent solution and said admixture at approximately said second temperature.

90. A device for treating a material, comprising:

an apparatus which forms an ozone-solvent solution at a first temperature and which comprises an outlet that delivers a supply of said ozone-solvent solution at substantially the first temperature;

an applicator fluidly coupled to the outlet of said apparatus to receive said supply of said ozone-solvent solution at substantially said first temperature, said applicator having an outlet configured to direct said ozone-solvent solution onto said substrate;

a heater configured to heat said material to a second temperature higher than said first temperature while said ozone-solvent solution is being directed onto said substrate.

91. The device of claim 90, wherein said heater comprises a radiant heater configured to direct electromagnetic radiation toward said material.

92. The device of claim 90, further comprising a holder configured to hold said material in proximity of said applicator.

93. The device of claim 92 further comprising a processing module that contains said applicator outlet and said holder.

94. The device of claim 92, wherein said holder comprises a chuck that is configured to hold a flat substrate.

95. The device of claim 92 wherein said material comprises a semiconductor wafer, and wherein said holder comprises a wafer chuck.

96. The device of claim 95 further comprising a motor coupled to spin said wafer chuck.

97. The device of claim 91 further comprising an window located between said radiant heater and said material.

98. The device of claim 90 further comprising a temperature sensor that provides an indication of the temperature of said material.

99. The device of claim 98 further comprising a temperature controller responsive to said temperature sensor and coupled to control the temperature of said material.

100. An ozone-solvent solution supply comprising:

an ozone source;

a solvent source;

an ozone-solvent contactor having an inlet coupled to receive solvent from said solvent source, an inlet coupled to receive ozone from said ozone source, and an outlet for ozone-solvent solution formed by said ozone-solvent contactor; and

an ozone-solvent solution heater coupled to receive said ozone-solvent solution from said outlet, said heater configured to heat said ozone-solvent solution, said heater having a heater outlet for supplying heated ozone-solvent solution.

101. An ozone-solvent solution supply comprising:

a source of an ozone-solvent solution initially formed at a first temperature; and

a heating element coupled to receive said ozone-solvent solution, wherein said heating element is capable of heating said ozone-solvent solution from said first temperature to a second temperature at rate to create a heated ozone-solvent solution such that said heated ozone-solvent solution has a higher dissolved ozone concentration than if said ozone-solvent solution had been initially formed at said second temperature.

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102. A system for treatment of an article for the purpose of sterilization, disinfection, or surface modification thereof, comprising:

a chamber adapted to hold said articles to treated, said chamber having a chamber inlet and interior surfaces;

a source of an ozone-solvent solution initially formed at a first temperature;

a heating element, coupled to receive said ozone-solvent solution from said source, wherein said heating element is capable of heating said ozone-solvent solution from said first temperature to a second temperature at rate to create a heated ozone-solvent solution such that said heated ozone-solvent solution has a higher dissolved ozone concentration than if said ozone-solvent solution had been initially formed at said second temperature;

said chamber inlet coupled to receive said heated ozone-solvent solution from said heating element;

a nozzle disposed to apply said heated ozone-solvent solution to said article and the interior surfaces of said chamber;

a chamber drain which is disposed to drain the ozone-solvent solution from the chamber, said drain comprising a backflow preventer which prohibits the introduction of unsterile fluids into the chamber;

said chamber further comprising a chamber sterile air inlet configured to admit sterile air into the chamber through a sterile filter;

said chamber further comprising a chamber vent that is configured to vent gases from the chamber, said chamber vent having a backflow preventer configured to prohibit the introduction of unsterile fluids into the chamber.

103. The system of claim 110/102 further comprising a plurality of nozzles disposed to apply said heated ozone-solution at a plurality of locations onto said article.

104. A system for treating a substrate with an ozone solvent solution comprising;

a substrate loading port;

a first treatment module for treating substrates with a heated ozone solvent solution, said treatment module further comprising:

a source of an ozone-solvent solution at a first temperature; and

means for reacting the ozone-solvent solution with the substrate at a second temperature greater than the first temperature;

a second treatment module for treating the substrate with a complementary treatment process;

a robot for transferring substrates from the loading port to at least one of said first and second treatment modules.

105. A system according claim 104 where the complementary process is a plasma based organic removal process.

106. A system according claim 104 where the complementary process is a plasma-based dielectric or conductor etch process.

107. A system according claim 104 where the complementary process is a solvent based wet process.

108. A system according claim 104 where the complementary process is an aqueous based wet process.

109. A system according claim 104 where the complementary process is a resist application process.

110. The method of claims 1-40, claim 51-76, wherein said solvent comprises water.

111. The method of claims 1-40, claim 51-76, wherein the pH of said ozone-solvent solution is pH adjusted to between about 5 and about 10 with an acid, a base, or a buffer.

112. The device of Claim 48 wherein the heater comprises a convection heater which provides a heated fluid, and wherein said material comprises a substrate having two opposing sides, and wherein the heated fluid is applied to a side of the substrate opposite to that to which the heated ozone-solvent solution is applied.

113. The device of Claim 48 wherein the heater comprises a radiant heater , and wherein said material comprises a substrate having two opposing sides, and wherein the radiant heat a is applied to a side of the substrate opposite to that to which the heated ozone-solvent solution is applied.

114. The device of Claim 48 wherein the heater comprises a radiant heater , and wherein said material comprises a substrate having two opposing sides, and wherein the radiant heat a is applied to a side of the substrate to which the heated ozone-solvent solution is applied.

115. The device of Claim 48 wherein the heater comprises a heated chuck, and wherein said material comprises a substrate having two opposing sides, and the heated chuck is applied to a side of the substrate opposite to that to which the heated ozone-solvent solution is applied.